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Editor Dr. Clayton M. White, Dept. of Zoology, 161 WIDB, Brigham Young University, Provo, Utah 84602

Editorial Assistant Joan W. Boyce, 159 WIDB, Brigham Young University, Provo, Utah 84602

Editorial Staff Dr. Frederick N. Hamerstrom, Jr. (Principal Referee)

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International Correspondent Dr. Richard Clark, York College of Pennsylvania, Country Club Road, York, PA 17405

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BIOLOGY OF ELEONORA'S FALCON (*FALCO ELEONORAE*):

1. INDIVIDUAL AND SOCIAL DEFENSE BEHAVIOR

by

Dietrich Ristow

Pappelstr. 35, D-8014 Neubiberg

Federal Republic of Germany

and

Coralie and Michael Wink

Institut für Pharmazeutische Biologie der Technischen Universität

D-3300 Braunschweig

Federal Republic of Germany

Abstract

Most Eleonora's Falcons breed colonially on some small islands in the Mediterranean Sea. Falconiformes, owls, and crows, but not gulls are attacked socially and effectively ward off. Such mobbing occurs outside the limits of breeding territories. Ground predators, on the other hand, are attacked by individual falcons rather than by social mobbing, although this group of predators causes the major losses of falcon broods.

Introduction

Species of the genus *Falco* that are solitary are generally territorial and attack potential predators near their nest (Brown and Amadon 1968). Certainly, this is also true for Eleonora's Falcon (*Falco eleonorae*), but as a consequence of its colonial breeding, social mobbing can be observed (Mayol 1977, Walter 1978, 1979). Sociality in this falcon does not seem to be highly advanced as compared to other social animals and therefore, they offer an opportunity to study one stage in the evolution of social behavior. In this report, we describe social mobbing and its limitations by territoriality. We distinguish aerial predators as those that can fly and which are usually encountered outside the individual breeding territories, and ground predators as those inside the territories as potential predators of eggs or young falcons.

Materials and Methods

We visited a falcon colony in the Aegean sea on 5 expeditions from 1965 to 1977 and spent a total of 5½ months there during the breeding seasons. Our observations covered the interval from the first week of July to the middle of October. The colony was situated on an uninhabited island approximately 0.5 by 1.0 km in size and about 20 km from the nearest large island. There were about 180 pairs of falcons each year. As we lived in a cave in the midst of the breeding territories, we were aware of events almost continuously and recorded every encounter with intruders on the colony. Encounters with harmless species such as hares and lizards were recorded. Experiments with stuffed birds, rats, plastic snakes, and a plastic kite bearing the silhouette of an eagle were conducted. These experiments were carried out after the chicks were at least 10 days old.

Results

Defense against aerial predators

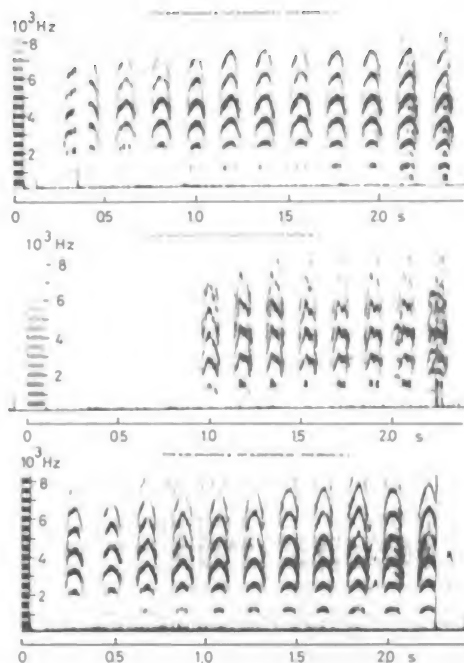
During the autumn breeding season, potential predators such as other raptors or crows approach the falcon colony on migration. In such situations, a fright call is sometimes given once or twice (a shrieking "kraiere" with the accent on "i"). At the same in-

stant the falcons leave their nests or resting sites and start to give intensive excitation or alarm calls, like a nagging "yek-yek-yek . . .," in males pitched higher than in females (Fig. 1). The island size and the noise of wind and sea make it difficult to quantify the use of the fright call. We have the impression that when it is used, more than 100 falcons join in mobbing; when it has not been used and only excitation calls are given, about 20 to 50 falcons attack. Falcons, calling excitedly, gathered above the predator and individuals repeatedly dived from 5 to 10 m behind it, aiming at the shoulder. Although a direct hit was observed only once (in the case of a Short-Eared Owl, *Asio flammeus*), the mobbed bird attempted to evade the attacks and flew away from the island. There seems to be no difference in the intensity of mobbing when the falcons had eggs or chicks.

In three experiments with a plastic kite (eagle silhouette) about 12 falcons gathered above it, as soon as it was more than 20 m from the ground. They did not call, but performed several stoops, and soon lost interest.

A striking change in behavior was observed when, in spite of the mobbing group, a Steppe Eagle (*Aquila rapax*) landed inside the territory of a pair of falcons with young

Figure 1.—Sonagram of excitation call of Eleonora's Falcon; 80–5000 Hz, bandwidth 300 Hz.



a) Male voice. Notice the slight increase of frequency with time; the increase in intensity is most pronounced for the fundamental frequency and the uppermost harmonics. The female enters synchronously for the last three calls shown, the call being deeper and shorter. For other female individuals the call can have the same length and the same fundamental frequency as the call of this male. However, for females the relative intensity of the fundamental frequency as compared to the harmonics is always greater than for males.

b) Excitation call of another male. Notice the higher frequency and the varied pattern as compared to a). Again the female enters for the last two calls shown.

c) Female call.
(A sound recording of the fright call is not available.)

about 10 days old. The other falcons retreated to their own territories and only this pair and the neighboring pair continued their excitation calls and attacks. When the eagle took flight, it again elicited the usual mobbing response.

The impression that social mobbing occurs outside of the individual nest territories was supported by the following experiment. A stuffed Carrion Crow (*Corvus corone*) was placed in turn near 10 nests with chicks. At 9 nests it produced no obvious response from the adults. At the tenth nest, the female started calling excitedly a few seconds after the dummy had been put down, flew towards it almost horizontally, hit it on the shoulder with its talons during flight, flew in a circle and hit it again. Then it hovered 5 m above the crow, dived vertically to about 1 m from the crow and soared up. This behavior is similar to that of the Peregrine Falcon (*Falco peregrinus*) and Merlin (*Falco columbarius*) towards possible terrestrial predators (Brown and Amadon, 1968). The excited female did not evoke any response from other pairs. Even the male rested and called only occasionally while the female pounced onto the dummy every 10–20 seconds. It made no difference whether the crow was placed at this nest or 10 m away still within this female's territory. The attacks were continued after the crow had been knocked over. After its removal, the female sat in the territory, often at the nest, and kept calling for another 15–20 min. The fright call was not heard under these conditions, and no response to other dummies could be obtained prior to or after experience with the crow. When we repeated the experiment 1 week later, the crow was again singled out.

The behavior towards other possible predators of eggs or young is not so overt. Other falcon species, herons, and gulls (see Table 1) are allowed to land on the island provided they stay about 50 m away from the nearest nest. However, 20 to 50 m is the usual size of the radius of the nesting territory (see Walter 1979). When they landed closer to a

Table 1. Frequency (during 5½ months) of possible aerial predators closer than 1 km to the colony of Eleonora's Falcon, compared to the frequency of defensive behavior by falcons.

	Total observations	Individual defense response	Social mobbing
Accipitridae			
Strigidae	23 ¹	0	22
Corvidae			
Falconidae	13 ²	4	2
Ardeidae	15 ³	2	0
Laridae	> 500 ⁴	2	0

¹*Aquila rapax*, *A. clanga*, *A. pomarina*, *Hieraaetus fasciatus*, *H. pennatus*, *Milvus migrans*, *Circus aeruginosus*, *Circus gallicus*; *Asio flammeus*; *Corvus corax*

²*Falco peregrinus*, *F. tinnunculus*, *F. naumanni*. In addition to these observations a dead *F. tinnunculus* was found on the island and a *F. naumanni* was fed to chicks.

³*Ardea cinerea*, *A. purpurea*, *Egretta garzetta*, *Ardeola ralloides*, *Bubulcus ibis*, *Nycticorax nycticorax*

⁴*Larus argentatus*, *L. audouinii*

nest, single pairs or individuals attacked them with or without excitation calls. Individual attacks on gulls in a Moroccan colony (Clark 1974) seem to be more frequent than in the Aegean colony we studied.

A stuffed Herring Gull (*Larus argentatus*) placed in turn near 10 nests elicited no reactions from the falcons. Even a pair that had attacked a gull in flight near their territory did not respond to the dummy near their nest.

About 1% of the falcon broods are lost accidentally to Cory's Shearwater (*Calonectris diomedea*) when the falcon's nest is in the entrance of a shearwater's crevice. However, adult shearwaters passing close to the island are only on exceptions chased for a few seconds by a single falcon. Apart from such accidents, no eggs, young or adult falcons were lost to aerial predators.

Defense against terrestrial predators

To understand the limits of social defense behavior, we briefly describe the behavior against possible ground predators. Such predators include man, rats, and to a lesser extent, snakes.

Eggs are sometimes taken by egg collectors, while young falcons are taken by hunters and local fishermen to eat as a delicacy. When we approached a territory, no mobbing by a group of falcons was elicited. Individual birds behaved as follows: As long as only eggs were present, the incubating falcon (usually the female) flew off and circled 5–40 m above the site. After the young had hatched, the female also gave excitation calls. The older the young, the more intensive the call, especially when young began to scream. Circling was interrupted by occasional raids at the intruder but without it being hit. Neighbors did not join the pair in defense, although toward the end of the breeding season falcons came to circle and call together when we appeared, but they soon lost interest. Three goats (*Capra hircus*) living on the island during 2 seasons were treated in the same way as human beings only once. Hares (*Lepus capensis*) were never molested.

Trapping and banding alerted the falcons, but otherwise they did not respond to the threat of being caught and they never screamed while handled. One pair was caught repeatedly in the same and in different seasons, both when they had eggs as well as when they had 2 weeks old chicks. No increase in defensive reaction of either partner was noticed when we entered their territory repeatedly. This was also true for the 20+ pairs where one member was trapped while the remaining bird watched.

Density of rats (*Rattus rattus*) on the island varies from year to year, but appears to be constantly high, for we caught 5 rats in a single night with 1 trap. About 20% of falcons' eggs are destroyed by rats (Wink et al., 1979). Although rats prowled in the shade as early as late afternoon, we did not observe predatory or defensive behavior by falcons toward rats, nor did we hear conspicuous falcon calls during the night that would suggest predation. Lizards (*Lacerta erhardii*) are usually tolerated and may creep under the female's wing and tail in search of ectoparasites or sunbathe on her tail. They are sometimes caught and killed, but not eaten. Dried lizard carcasses were found in about every 15th nest. Rat carcasses were absent from nests. No defense response was elicited in experiments with a stuffed rat.

A snake has been vigorously attacked in a Moroccan colony (Clark 1974). No snakes were on the island we studied, so we could only test the falcon's response by pulling a plastic snake with a piece of string close to a nest with female and chicks. The bird flew off without calling. Placing the dummy at other nests had no obvious effect.

Discussion

How can we explain that Eleonora's Falcons have such an effective defensive mobbing behavior against aerial predators, but do not show similar response to rats feeding on unattended eggs? We assume that rats appeared only recently on the island and that specific reactions have not yet evolved. The falcons' indifference to being caught by us reminds us of other species on islands without terrestrial predators, for example, the Galapagos Islands.

Mobbing has been studied in various birds (Shalter 1978) and is most prominent in colonial species. Social mobbing in the case of Eleonora's Falcon is similar but the situation is more complicated than for terns (*Sterna* sp.) or bank swallows (*Riparia riparia*) (Hoogland and Sherman, 1976). Although the Eleonora's Falcon breed colonially, they nevertheless have individual territories similar to solitary breeding falcons in which neighbors are not tolerated (Walter 1978). Social mobbing is limited by this behavior: as soon as an aerial predator is within a territory, social reaction ends and only individual attack continues. This seems to be true for ground predators as well. Individual attack is comparable with that of solitary falcons and is effective considering the size of Eleonora's Falcon (female weight 390 g).

We assume that due to ecological adaptation, Eleonora's Falcon developed from a solitary species to a colonial species. Originally, predators may have been deterred by the individual action of several falcons. When selection pressure from the presence of predators (the autumn breeding season coincides with the increased number of raptors passing on migration) is the same or higher as compared to a solitary falcon (Table 1), then defense could improve by changing to social mobbing. We suggest that important components of social behavior are the stimulating effect of fright calls and possibly the excitation call. Finally, there is the effectiveness of social mobbing. It is difficult to quantify the degree of sociality reached so far in this species. An effective way to test advantage of social mobbing would be to establish a correlation between colony size and effectiveness as has been done for bank swallows (Hoogland and Sherman, 1976).

Acknowledgments

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Part 1 of a series on Eleonora's Falcon.



Description of Photo—

Nest defense: Female Eleonora's Falcon hits a stuffed Carrion Crow placed at falcon nest. (see p. 67).

NESTING OF THE GREATER KESTREL *FALCO RUPICOLOIDES* IN ZAMBIA

by

Timothy O. Osborne

Alaska Department of Fish and Game

Box 155

Galena, Alaska 99741

and

J. F. R. Colebrook-Robjent

Musumanene

Box 303

Choma

Zambia

Abstract

Breeding data were obtained from 10 pairs of Greater Kestrels at Minyanya Plain, Zambia, during September 1975. Black Crow nests were the only nesting platforms utilized, and we concluded that they were acquired aggressively by the kestrel. Sixty % of the nests kestrels used had been built by crows during the 1975 season indicating a frequent occurrence of nest piracy. Incubation was undertaken by the female which was very shy on the nest. The distance between nests averaged 2.3 km, slightly more than the distance between all crow nests. The breeding distribution and nesting density of the Greater Kestrel in Zambia is directly influenced by the distribution and density of the Black Crow.

Introduction

Benson et al. (1971) summarized the distribution of the Greater Kestrel (*Falco rupicoloides*) in Zambia and noted that there were no breeding records. Aspinwall (1979) recorded the first nest of the species in Zambia which contained 4 fresh eggs on 30 August 1974 at Mitashi Plain (13°35'S., 22°50'E.), western Zambezi (formerly Balovale) District. The eggs were laid in an old nest of a Black Crow (*Corvus capensis*). The status of the Greater Kestrel in Zambia has been discussed briefly in a previous paper (Osborne and Colebrook-Robjent 1980). This paper presents breeding data on an undisturbed population of Greater Kestrels at Minyanya Plain, Zambia.

Study Area and Methods

Minyanya Plain (13°09'S., 22°23'E.) is a watershed *Loudetia* grassland lying between the North and South Kashiji Rivers in Zambezi District, North-Western Province, Zambia. The plain, approximately 1150 m above sea level, is bordered on the north by the North Kashiji floodplain; to the south and west by broken stands of *Diplorhynchus* woodland and to the east by degraded Kalahari (*Baikiaea*) woodland. The soils are Barotse sands with an uneven surface due to numerous *Cubitermes* mounds. Scattered over the plain are solitary trees or sparse clumps of trees rarely greater than 6 m high.

From 10-15 September 1975 we located all raptor and crow nests within a 5 km radius of our camp site in a small isolated stand of *Syzgium* just north of an east-west track which bisected the plain (Fig. 1). The open nature of the plain and the low stature of the trees enabled us to find all the nests. On 15 September we drove a transect SSE 60 km towards South Kashiji School and examined every nest we saw.

Results

Ten pairs of kestrel were located in the study area (Fig. 1). In addition, 3 single kestrels were observed on the edge of the study area. All 10 pairs were associated with either new or old nests constructed by Black Crows. The crow nests were within the upper canopy of the tree and were composed of a platform of sticks usually lined with animal hair.

Of 19 crow nests in the study area, 4 were old and unoccupied, 5 contained kestrel eggs, 2 contained Black Crow eggs, 2 contained Black Crow nestlings, 2 were under construction by crows, 2 were new nests with kestrels in attendance, and 2 were old nests with kestrels in attendance. We attributed one nest which contained broken eggs and appeared deserted to a kestrel pair which was perched 500 m away.

We observed incubation only by females. They allowed us to approach to within 250 to 400 m of the nest before flying unobtrusively away, just above ground level, out of sight. One female kestrel vigorously defended her empty nest every time we examined it, but neither this bird nor any other kestrel ever uttered a call.

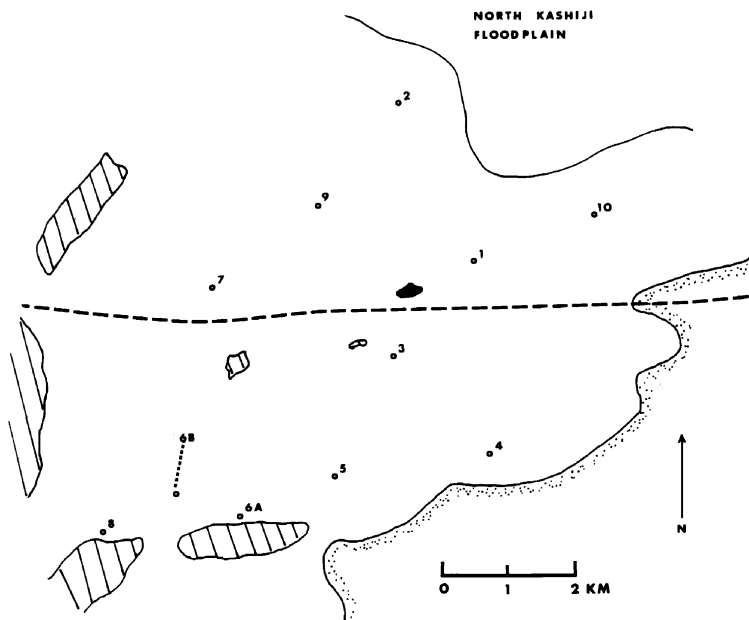


Figure 1.—Location of Greater Kestrel nest sites at Minyanya Plain, Zambezi District, Zambia, September 1975. The plain is bisected by a motor track; the *Diplorhynchus* woodland is shown crosshatched; the *Baikiaea* woodland stippled, and the *Syzigium* stand is black.

The average distance between kestrel nest sites was 2.3 km; the density was one nesting pair per 415 ha. The nesting activities of the kestrel pairs are summarized in Table 1. Clutch size of the kestrel was three C/4 and two C/2. Egg laying started at the end of August (Aspinwall 1979) and continued past mid-September. The average weight of seven unincubated eggs was 24.2 g (23.1–27.0 g). Measurements of 26 eggs averaged 41.5 by 32.7 mm (range 39.4–43.3 by 31.4–34.6 mm). These Zambian Greater Kestrel egg measurements, which included Aspinwall's (1979), are smaller than the averages given in McLachlan and Liversidge (1978).

On our transect towards South Kashiji School, we found 13 Black Crow nests, 4 of which were occupied by kestrels.

The Black Crows at Minyanya bred over an extended season. We found nests containing large young (eggs laid in early August), and nests still in the early stages of construction. Like Aspinwall (1979) and White (1946) we found the crows to be very shy, and

Table 1. Summary of Greater Kestrel nests at Minyanya Plain, Zambia, September 1975

Pair	Nest site	Contents	Notes on the kestrels
1	New crow nest 4.5 m high in leafy <i>Parinari mobola</i> , crow recently dispossessed	nil	Female unusually aggressive when nest inspected 12 Sept. Still empty 1000 h 15 Sept.
2	Old crow nest 2.4 m high in small defoliated tree	C/4	Three eggs 10 Sept. fourth egg laid before 0700 h 13 Sept.
3	Old crow nest 2.1 m high in small defoliated tree	nil	Pair at nest 10 to 15 Sept.
4	New unlined crow nest 4.2 m high in medium-sized tree. Nest still unlined 14 Sept.	nil	Pair perched nearby 11 Sept.
5	New fully lined crow nest 4.8 m high in solitary 'Mukutanlonga' tree, partly defoliated	2 eggs	No eggs 11 Sept. first egg laid before 1000 h 12 Sept., second egg laid before 1400 h 14 Sept.
6A	Old crow nest 4.5 m high in solitary medium-sized tree	1 or more eggs	Deserted nest with one egg and remains of others 12 Sept.
6B	Incomplete new crow nest in solitary tree	nil	Pair perched 500 m north 12 Sept. probably pair from failed nest 6A
7	New crow nest 5.4 m high in partly defoliated tree	C/3	12 Sept.
8	New crow nest in medium-sized tree	nil	Pair 100 m from nest 12 Sept.
9	Old crow nest 5.4 m high in partly defoliated tree	C/4	Freshly plucked button quail <i>Turnix sylvatica</i> remains on ground near nest site 13 Sept.
10	Old and delapidated crow nest 3 m high partly tipped over	nil	Kestrel perched nearby 10 Sept.

we were not able to observe any pairs at their nests. The density of the crows averaged 381 ha per nesting pair, considerably larger than the 60 ha average found in South Africa (Skead 1952).

Discussion

The Greater Kestrel uses the nests of crows or hawks in South Africa (McLachlan and Liversidge 1978); however, the Minyanya population of Greater Kestrels in Zambia has developed a restrictive breeding strategy in which Black Crow nests are exclusively utilized as the nest site.

We concluded that when a suitable nest site was not available within the kestrel's home range, the pair waited until a Black Crow built a nest and then pirated it. Of the 10 pairs of kestrels we observed, 2 were quietly perched 100–200 m away from crow nests under construction. Although we do not have direct observations of nest piracy, it was frequent because 60% of the kestrels were using nests built during the 1975 nesting season.

The average distance between crow nests built in the 1975 season irrespective of the present occupant (either crow or kestrel) was 2.3 km. When this is compared with the 2.3 km we found between kestrel nests, it is apparent that the density of the kestrel nests is directly related to the density of crow nests. Once the minimum requirement of a nest site is satisfied, other factors, such as food, must affect density since the total crow nests outnumbered the nests occupied by kestrels.

A review of the genus *Falco* in Zambia indicated that perhaps breeding density is influenced by "host" nest site density in several other species. In parts of the range of the Red-necked Falcon (*F. chicquera*), a Pied Crow (*Corvus albus*) nest is the nest platform (Colebrook-Robjent and Osborne 1974). On the Kafue Flats a relationship between falcon and crow density is suspected (pers. obs.). In large areas of Zambia and Zimbabwe, where rock outcrops do not exist to provide cliff faces, the Lanner Falcon (*F. biarmicus*) nest in new or old Bateleur (*Terathopius ecaudatus*) nests (pers. obs., Steyn 1980).

The distribution of the Greater Kestrel in Zambia as stated by Benson et al. (1971) implies that the bird is widespread in suitable habitat throughout the south and west of the country. Their records mainly covered the period of July to October, and, since no nests had been discovered, they suggested that most kestrels found in Zambia were derived from Botswanan birds driven north during the cold dry season. However, with our knowledge of kestrel nest site preferences, a distinction must be made not in the date of the observation but whether or not the record occurs within the known range of the Black Crow. Kestrel records from elsewhere in Zambia (Fig. 2), regardless of the date, can be assumed to be wandering birds.

It is not possible to discuss the breeding distribution of the Greater Kestrel in Zambia without reviewing the distribution of its nest building "host," the Black Crow. The range of the crow in Zambia (Benson et al. 1971) parallels the distribution of the watershed grassland vegetation type found west of the Zambezi River and north of the Kalabo River (Fig. 2). There are further crow records from Konkano Plain (13°15'S., 24°00'E.), also a watershed grassland, and from Livingstone, but the latter record is thought to be an escape (Benson et al. 1971). It is not known what element in the watershed grassland determines its suitability to the crow. The distribution of the kestrel shows a concentration of records from these same grasslands. We expect the kestrel will be found as a breeding species on the Konkano Plain.

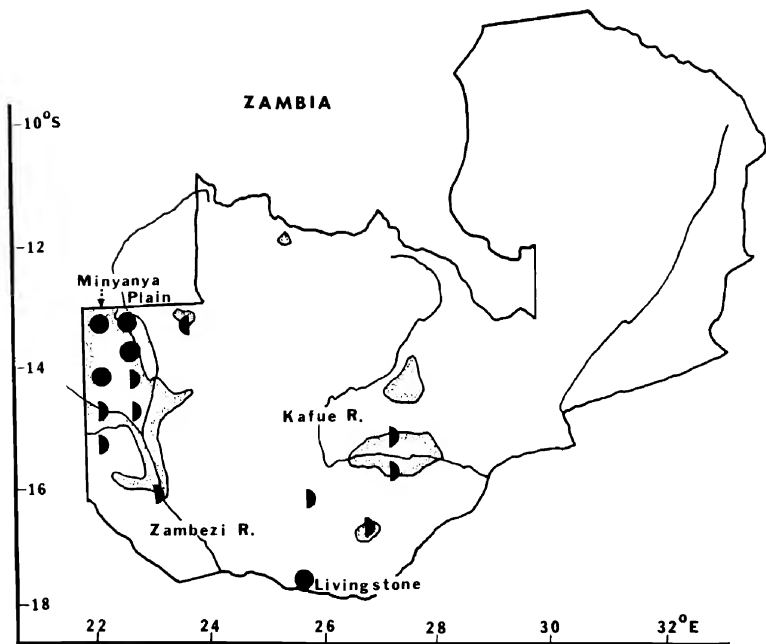


Figure 2.—Distribution of Greater Kestrel in Zambia. Watershed and floodplain grasslands of the western half of the country represented by stippled area. Locations where Greater Kestrels have been collected or sight records are represented by the symbol (◐). Locations where Black Crows have been collected or sight records are represented by the symbol (●). From National Museums of Zambia Provisional Bird Atlas species numbers 112 and 384 (courtesy R. J. Dowsett).

The Black-shouldered Kite (*Elanus caeruleus*) was common on the North Kashiji floodplain, the northern border of our study area, but we did not observe any on Minyanya Plain. Likewise Britton (1970) considered it was probably absent from watershed plains in the District. Conversely, we failed to find any kestrels on the floodplain. Since both species prey on similar food items (mice and insects) (McLachlan and Liversidge 1978), exclusive territories were not expected. Possible reasons for the exclusion could be inter-specific aggression, competitive exclusion or a different hunting technique. The hovering hunting style of the kite may give it an advantage on the floodplain where grasses are taller than on the plain.

The differences in the average egg size between Minyanya and South African kestrels suggest that the Zambian kestrels may be smaller. We measured an additional 46 eggs of the kestrel from Transvaal; their average 42.5 by 34.2 mm (range 40.0–44.6 by 32.3–35.7 mm) falls between the Minyanya and South African eggs suggesting a size cline. However, a comparison of wing lengths does not show a significant difference. The wings of four females collected in Zambia averaged 280 mm (range 273–289 mm) (Benson and Irwin 1967, Aspinwall 1979) and 18 southern African females average 282 mm (range 272–290 mm) (McLachlan and Liversidge 1978). More data are needed to clarify this issue.

Summary

The breeding distribution of the Greater Kestrel in Zambia is very restricted. The breeding strategy of the kestrel restricts it to regions where its nest building "host," the Black Crow, nests. The density of kestrel nests on Minyanya Plain is related to the density of crow nests. The breeding season commenced in August, and some pairs had not laid eggs by mid-September. The average egg size was smaller than South African birds suggesting a difference in the size between the birds.

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AGE AND WEIGHT ESTIMATION OF LEPORID PREY REMAINS FROM RAPTOR NESTS

by

Neil D. Woffinden

Division of Natural Sciences

University of Pittsburgh at Johnstown

Johnstown, PA 15904

and

Joseph R. Murphy

Department of Zoology

Brigham Young University

Provo, UT 84602

Introduction

The black-tailed jackrabbit (*Lepus californicus*) is a major prey species for several Great Basin raptors (Smith and Murphy 1979). Jackrabbit hindfeet are the most common prey remains recovered from Ferruginous Hawk (*Buteo regalis*) and Golden Eagle (*Aquila chrysaetos*) nests in our study area. Ages (up to 16 weeks) and weights of jackrabbit prey can be determined by comparing length of hindfeet with published values (Haskell and Reynolds 1947, Tiemeier and Plenert 1964 and Goodwin and Carrie 1965).

We routinely made such comparisons for Ferruginous Hawk prey remains during 1972-74 (Woffinden and Murphy 1977). Nests were visited frequently and prey remains collected and measured before they dried extensively. Frequent nest visits are not always practical, however. Since jackrabbit feet may grow as little as 1 mm per week (Haskell and Reynolds, 1947; Tiemeier and Plenert, 1964; Goodwin and Carrie 1965), shrinkage due to drying could result in serious underestimation of prey ages. Here we present a regression equation which allows for shrinkage compensation.

Study Area, Methods and Results

Our study area is in west-central Utah (40°00' N., 110°55'-112°35' W.) and includes portions of Utah and Cedar valleys. The habitat is typical Great Basin cold desert with sagebrush (*Artemisia tridentata*) and Utah junipers (*Juniperus osteosperma*) among the dominant plants.

We collected 10 hindfeet from 8 different fresh road-killed jackrabbits on 27 June 1980. Based on published data of morphological characteristics, the rabbits varied in age from 8-32 weeks. Feet were secured to the east side of a building and were measured periodically over a period of 43 days as they dried.

Seventy percent of the shrinkage (6.1 mm or 6% of the mean total length) occurred within 14 days. Mean maximum shrinkage was 8.9 mm, which was equivalent to 7.2% of total length and occurred within 28 days.

Wet and dry lengths were linearly related ($t = 6.037$ $P = 0.05$). Thus we calculated a regression equation that allows for the estimation of lengths prior to drying ($\hat{y} = -3.578 + 1.113X$, 95% C.I. $\times 1.113 \pm 0.425$, Fig. 1).

Discussion

Jackrabbit hindfeet are commonly found as prey remains in many raptor nests. By comparing rabbit foot lengths with published values (see citations above) prey ages and corresponding weights can be determined up to a maximum of 16 weeks.

We frequently collected prey remains from Great Basin Ferruginous Hawk nests during a three year study (1972-74) during which time feet of 71 jackrabbits were collected

and aged using the method described above. Nearly 90% of the rabbits taken as prey were less than 13 weeks of age (Woffinden and Murphy 1977).

In June, 1980 we found a Golden Eagle nest that was littered with jackrabbit remains. The young had previously fledged, but we estimated that at least 47 jackrabbits had been brought to the nest during their development. The jackrabbit feet were very dry, and we assumed some shrinkage had occurred.

To account for loss of length in drying we developed the regression equation presented in this paper (Fig. 1). We determined prey ages based on calculated wet lengths and found that unlike the prey of Ferruginous Hawks, 79% of the jackrabbits utilized by this pair of eagles were older than 12 weeks.

We feel that the shrinkage equation presented here will facilitate accurate age determination of dry leporid prey remains. The technique may also reduce the need for frequent nest visits resulting in a reduction of stress-related mortality.

Acknowledgments

This work was supported by a grant from the University of Pittsburgh at Johnstown. L. W. Woffinden provided field assistance and H. Callihan statistical advice.

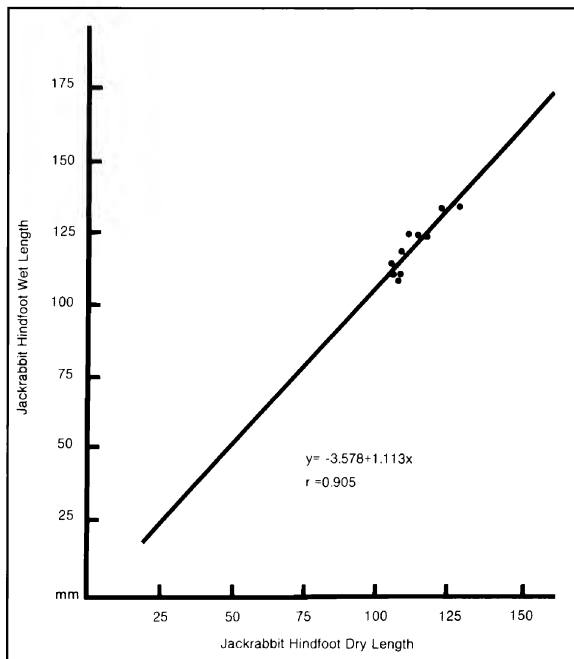


Figure 1.—Regression analysis of the relationship of jackrabbit hindfoot lengths before and after drying.

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ARE OWLS REGULAR?: AN ANALYSIS OF PELLET REGURGITATION TIMES OF SNOWY OWLS IN THE WILD

by

Peter C. Boxall and M. Ross Lein*

Department of Biology

University of Calgary

Calgary, Alberta T2N 1N4

Abstract

This study analyzes the temporal distribution of pellet regurgitation by wintering Snowy Owls (*Nyctea scandiaca*). Pellets were cast more frequently from 1400 to 1800 (MST) than during other daylight hours. The apparent regularity of this pattern of regurgitation and its relationship to the feeding time of the owls are considered.

Introduction

Research on the digestive process of owls has focused on the regulation of the meal to pellet interval (MPI). This interval appears to be important because owls do not possess crops and must empty their stomachs periodically in preparation for new food (Ziswiler and Farmer 1972). Duke and Rhoades (1977) have shown in the laboratory that the quantity of food ingested, the time of day that feeding occurs, and the nutrient composition of prey affect the MPI of Great Horned Owls (*Bubo virginianus*). Fuller and Duke (1979) have demonstrated that multiple feedings, spaced over a period of time (2-3 hrs), increase the MPI of captive Great Horned Owls.

Very few field observations of the interval between feeding and pellet regurgitation have been published. This note describes the temporal pattern of pellet casting by Snowy Owls (*Nyctea scandiaca*) in the wild, and uses results from laboratory studies of the digestive physiology of strigiforms to suggest the significance of this pattern.

*Send requests for reprints to M.R.L.

Methods

Observations of Snowy Owls were made during the winters of 1976-77 and 1977-78 near Calgary, Alberta. Approximately 200 hours of detailed observations of resident individuals, and over 400 hours of more casual observations, were made during daylight hours (0630-1800 M.S.T.). We recorded 15 instances of pellet casting. In each case we noted the time and the behavior of the owl, and collected the pellet for analysis of food habits. Because of the small number of observations, samples from both years are combined. The owls utilized a similar prey base, and maintained similar activity budgets in both years (Boxall 1980). *Peromyscus maniculatus* and *Microtus pennsylvanicus* were the prey recorded most frequently in pellets.

Results and Discussion

The temporal distribution of 15 pellet regurgitations is shown in Figure 1. An expected distribution was calculated on the basis of a random distribution of occurrences, corrected for the observation time during each period (Fig. 1). The observed and expected distributions differ significantly (Kolmogorov-Smirnov one-sample test; $p < 0.05$). Regurgitations were more frequent between 1400 and 1800 than at other times of the day (Chi-square test; $p < 0.01$). Almost 50% of the regurgitations were observed between 1400 and 1600.

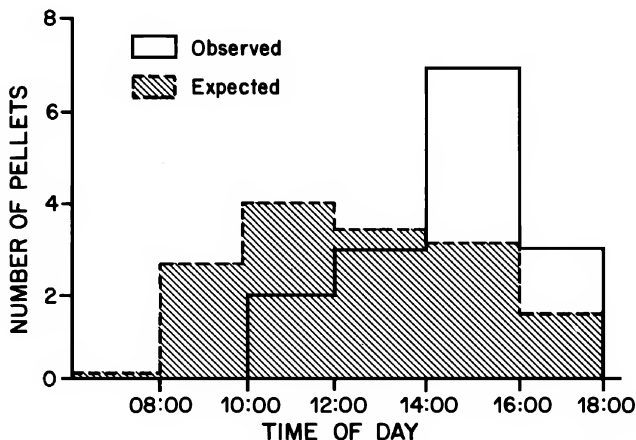


Figure 1.—The distribution of pellet regurgitations by time of day. Also shown is an expected distribution of regurgitations based on a random distribution by time period, corrected for observation time.

Snowy Owls on the wintering grounds are more active during the late afternoon than during other daylight hours (Keith 1960; Nagell and Fryklund 1965), and the owls that we observed in southern Alberta apparently do much of their hunting at this time (Fig. 2). Since the presence of a pellet in the stomach of an owl may prevent it from eating (Chitty 1938; Duke et al. 1976), one would expect that pellet regurgitation would occur prior to hunting. The owls that we observed appeared to do this. Pellets were cast between 1400 and 1800, shortly before the owls started hunting. In fact, in 5 of our observations the owls cast pellets from 5 to 30 minutes before they were observed to capture

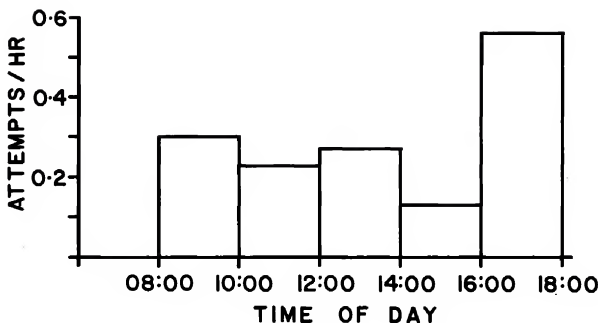


Figure 2.—Attempts by Snowy Owls to capture prey at different times of day, expressed as rates of capture attempts per hour of observation. Based on a sample of 36 attempts.

prey. On only one occasion was an owl seen to cast a pellet after capturing prey. This bird captured a mouse and spent about 5 minutes trying unsuccessfully to swallow it. The owl finally remained still for several minutes, cast a large pellet, and then swallowed its prey. Chamberlin (1980) describes a similar observation.

Duke et al. (1976) determined that the MPI of captive Snowy Owls fed at 0900 ranged from 7.9 to 16.2 hours. Chamberlin (1980), noting that Snowy Owls foraged primarily in the early morning (0730 EST) in Wisconsin, observed MPI's of 5.6 and 7.2 hours in the field. However, Chitty (1938) and Duke and Rhoades (1977) demonstrated that the MPI is significantly longer if the prey represented in the pellet are ingested in the late afternoon rather than early in the day. Furthermore, the amount of food ingested and its period of intake have been shown to influence the MPI of owls (Chitty 1938; Duke and Rhoades 1977; Fuller and Duke 1979). In our study, Snowy Owls captured small mammals more frequently than larger prey (Boxall and Lein 1982), and obtained these prey late in the day more frequently than early in the day (Fig. 2). Therefore, daily food requirements were probably met by ingesting several prey items over a period of time in the late afternoon and early evening. When captive Great Horned Owls were fed *Mus musculus* in this manner, the MPI ranged from about 19 to 22 hours (Fuller and Duke 1979). Most of the pellets that we observed being cast during the late afternoon probably represented prey captured over a 3–4 hour interval at about the same time the previous day. Chamberlin's (1980) much shorter MPI's are not directly comparable to our findings, due to the early feeding times of his birds. In addition, he does not provide data on the number of types of prey species recovered from the two pellets he observed being cast. Pellets containing one small prey item have been shown to be cast in less time than pellets representing several small items or one large prey item (Duke and Rhoades 1977).

Observations of prey capture and subsequent pellet regurgitation by birds of prey are very difficult to obtain, as evidenced by the small samples we obtained in comparison to the observation time. However, even the limited data we present are useful in extrapolating from laboratory results to the field situation.

Acknowledgments

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ANNOUNCEMENT

Raptor Diseases.

The Proceedings of the 1st International Symposium on Diseases of Birds of Prey, held in London on July 1-3, 1980, are now available. These Proceedings, entitled "Recent Advances in the Study of Raptor Diseases," contain the majority of the papers presented at the Symposium and cover subjects as diverse as behavior, toxicology, microbiology, anaesthesia, and surgery. Particularly relevant to those involved in the management of captive raptors are the sections on hand-rearing and laparoscopy, while the section on mortality factors in wild populations will be of value to ecologists. The publication updates the literature on raptor disease and discusses the latest developments in the field. It will have appeal to veterinarians, wildlife biologists, ornithologists, falconers, and aviculturists. Copies may be obtained from Chiron Publications Ltd., P.O. Box 25, Keighley, West Yorkshire, BD22 7BA, U.K. at 11 pounds (U.K. & Europe) and 12 pounds (elsewhere).

PREY CONCEALMENT BY AMERICAN KESTRELS

by

Keith L. Bildstein¹

Department of Biology

Winthrop College

Rock Hill, SC 29733

Abstract

Experimental studies with caged American Kestrels (*Falco sparverius*) indicate that the previously reported predominant dorsal orientation of cached prey may result from species-characteristic handling behavior during feeding, and that kestrels cache prey in more concealed locations when a potential food thief is present. Field observations reveal that kestrels hide prey they are feeding on when still hungry if they are about to be disturbed. These results and observations strongly support the notion that for kestrels, cache sites serve to hide as well as store uneaten prey.

Introduction

Caching behavior appears to be more widespread in owls (Collins 1976), than in diurnal raptors, where most observations are from the genus *Falco* (Mueller 1974). Caching is especially well documented in the American Kestrel (cf. Collopy 1977). Apparently kestrels continue to kill and cache food when satiated and cache sites act as storehouses against future uncertain prey availability, thereby insuring a more constant food supply (Stendell and Waian 1968; Balgooyen 1976; Nunn et al. 1976; Collopy 1977).

In addition to acting as storehouses, kestrel cache sites probably serve as hiding places for captured prey as both Collopy (1977) and Balgooyen (1976) noted that prey are usually cached dorsal side up in an apparent attempt to use the prey's countershading for concealment. Mueller (1974) found his captive birds reluctant to cache in the presence of either people or conspecifics. Here, I report results of laboratory experiments designed to test the hypotheses that (1) kestrels orient their cached prey to take advantage of the prey's countershading and (2) kestrels cache prey to hide it from approaching potential pirates (*sensu* Meinertzhagen 1959). I also report on field observations that show kestrels hide prey if they are about to be disturbed, even when apparently still hungry.

Methods and Materials

Laboratory study

I conducted laboratory experiments on 2 hand-reared, 2-year-old female kestrels and 1 wild-caught adult male kestrel. All experiments were conducted in a 1.5 × 1.5 × 2.0 m cage (Fig. 1). On test days kestrels were fed 6 g of beefheart 8 h prior to testing. This assured that they were relatively hungry at the time of testing. In experiment 1, a female and the male kestrel were fed 1 mouse, either a white or black laboratory mouse (*Mus musculus*) or a white-footed mouse (*Peromyscus leucopus*). The mice were dead and were placed alternately either dorsal or ventral side up in the center of the cage floor. The orientation of the cached remains were recorded. In experiment 2 a 35 cm² opaque partition was placed halfway between corners 1 and 4 (Fig. 1). The partition visually isolated corner 1 from my observation point across the room. In this experiment the male was offered a laboratory mouse of 22–33g. After the mouse was offered, a coin toss determined whether I left the room to return in 45 min or whether I remained in the room facing the kestrel while seated at a desk in plain sight 4.1 m from the cage. During observations, I remained in the room until the kestrel ap-

¹Second address: Belle W. Baruch Institute for Marine Biology and Coastal Research, USC, Columbia, SC 29208

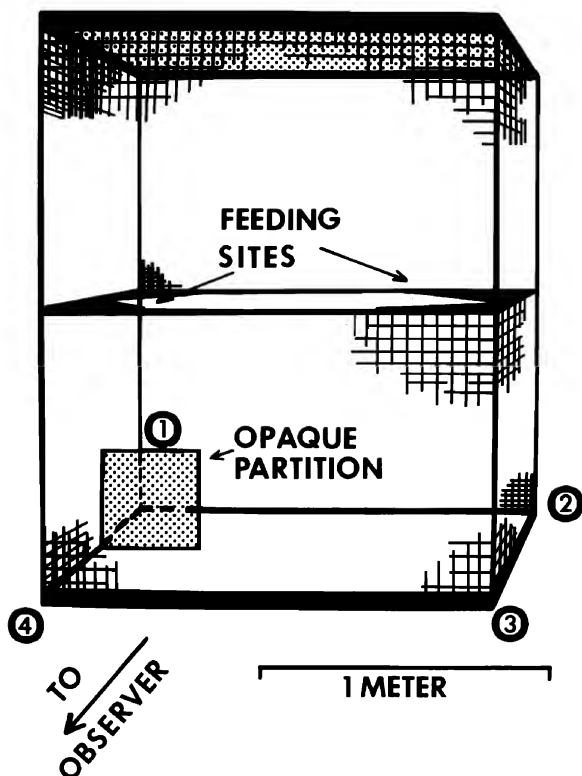


Figure 1.—Schematic of cage used in experiments 1 and 2. Circled numbers indicate corners in which kestrels cached prey.

proached, fed on, and either dropped the mouse or cached it. The location of the cached mouse and the approximate percent of mouse remaining were recorded. Prior to this experiment I practiced estimating the percent of mouse remaining from other kestrel feedings. Checks on these estimates indicated that I was able to predict within $\pm 10\%$ of the actual amount remaining 93% of the time. I later multiplied the estimated percent by the known weight of the whole mouse and subtracted that number from the whole body weight to determine grams consumed.

Field study

During the winters of 1979–81 I spent 28 h watching kestrels hunt on a salt marsh in Georgetown County, SC. Kestrels were observed at distances of from 15 to 150 m. Whenever a kestrel cached prey, I recorded species of prey, location of cache, and kestrel behavior before, during, and following caching.

Results and Discussion

Experiment 1

Experiment 1 was designed to test the hypothesis that kestrels orient their cached prey to take advantage of the prey's countershading. This hypothesis predicts that countershaded prey (e.g., white-footed mice) should be cached ventral side down while singled colored prey (e.g., white or black lab mice) should be cached with no preference for ventral side down. As the wild-caught male and hand-reared female tested did not differ significantly in this regard when caching either white ($P = .50$, Fisher's exact test) or black laboratory mice ($\chi^2 = .168$, $P > .50$) and as they showed no difference when caching white-footed mice (Table 1), I lumped their data and tested for the effects of pelage coloration on the orientation of cached mice. Neither mouse color (black versus white mice; $\chi^2 = .343$, $P > .50$) nor countershading (black and white lab mice versus white-footed mice; $\chi^2 = .465$, $P > .10$) significantly altered the tendency for kestrels to cache mice ventral side down. For all types of mice both kestrels cached all individuals with the anterior end stuffed into 1 of the 4 corners of the cage (Table 1). As both birds always ate the head of the mouse first, the anterior end invariably was the end that was broken into. Sixty-four % of the mice were cached ventral side down (Table 1).

Table 1. Orientation of white and of black laboratory mice and white-footed mice cached by two kestrels in experiment 1.

Orientation of carcass		Number of mice cached ^a			
side on floor	portion stuffed in corner	White lab	Black lab	White-footed	All mice
ventral	anterior	7/7 ^b	7/6	8/8	22/21
ventral	side	0/0	0/0	0/0	0/0
ventral	posterior	1/0	0/0	0/0	1/0
dorsal	anterior	1/2	2/2	1/2	4/6
dorsal	side	0/0	0/0	0/0	0/0
dorsal	posterior	0/0	1/0	0/0	1/0
lateral	anterior	1/3	1/4	2/2	4/9
lateral	side	1/0	0/0	1/0	2/0
lateral	posterior	1/0	1/0	0/0	2/0

^aThirty-six mice, twelve of each type, were presented to each of the kestrels.

^bWild caught male kestrel/captive-reared female kestrel.

In this experiment both kestrels manipulated their mice before feeding until they held the mouse ventral side down with its head extending in front of their talons. Both usually maintained this orientation throughout feeding although in several instances the prey was rotated to a side down position. After the birds flew to a corner to cache their prey

they transferred it to their beak and then stuffed it into the corner. During this sequence some mice were rotated to a dorsal or side down position. In none of these instances did the kestrel reorient the mouse in the cache site.

Experiment 2

Experiment 2 was designed to test the hypothesis that kestrels cache prey to hide it from potential pirates (*sensu* Meinertzhagen, 1959). This hypothesis predicts that kestrels should be less likely to cache prey when a potential pirate is present and that if they do cache then they should attempt to hide the prey. Although the weights of mice offered the kestrel when I remained in the room did not differ from those offered the bird when I left (Table 2), the kestrel consumed a greater amount when I remained than when I left (33% vs. 21%; Table 2). Although I watched the bird only when I remained

Table 2. Characteristics of prey cached and the caching behavior of a wild-caught adult kestrel during experiment 2.

Experimenter	p ^a		
	Left room (N = 34)	Remained in room (N = 40)	
Total weight of prey offered (grms)	25.6 ± 3.5	26.1 ± 5.7	0.50
Amount consumed (grms)	5.5 ± 2.7	8.6 ± 5.4	0.01
Arousal calling (Yes/no)	0/34	9/31	0.005
Cached in corner 1 ^b	18/53)	36/90)	0.005

^aProbability of a significant difference using a t-test (weight offered and amount consumed), Fisher's Exact test (arousal calling), or Chi-square test for heterogeneity (cache site).

^bN(Percent of total cached).

in the room following feeding and thus could not compare its behavior then to behavior when I left the room, it appeared nervous while feeding in my presence, especially immediately prior to caching attempts. At those times he often moved about from perch to perch (N=38, m=6±6.4 moves) prior to caching. On 2 occasions, he retrieved cached prey and resumed eating and on 2 other occasions he flew to a cache site only to return to a perch without caching. On 9 of the 40 trials in which I remained in the room the bird gave an arousal call ("klee-klee-klee"; Cramp 1980) either prior to or during the caching sequence. Arousal calling did not occur when I left the room following feeding (Table 2). In addition to these behaviors the kestrel also shifted the typical location of cached prey in my presence (Table 2). Whereas 90% of the cached prey were placed in corner 1 when I was present, only 53% of the cached prey were so placed when I left the room following feeding. As corner 1 was the only corner available for caching that was obstructed from my view (Figure 1) this result supports the notion that kestrels cache prey in sites hidden from potential pirates.

Field study

On 2 occasions kestrels I watched from a concealed position atop a 15-m tower-blind on a South Carolina salt marsh quickly ceased feeding on their Yellow-rumped Warbler (*Dendroica coronata*) prey and cached the remains when an auto approached within

100–150 m. In both instances the kestrels retrieved their prey and continued feeding within 4 min following the auto's passing. Finally, I watched an adult female Northern Harrier (*Circus cyaneus*) rob a male kestrel of an unidentified passerine it was attempting to cache in a detrital rack along the salt marsh edge. The kestrel had been feeding on an exposed post along the marsh edge when it darted to the detrital rack 15 m off and began caching its prey only to be followed by the harrier.

Summary of results and general discussion

In Experiment 1 kestrels changed the orientation of their prey when they were feeding but not when they cached it. Based on these observations I suggest kestrel prey-handling behavior during feeding, rather than an attempt by kestrels to adjust their prey to take advantage of the prey's countershading during caching, better explains observations of kestrels caching prey ventral side down. Upon capture, falcons characteristically bite the nape or back of the skull of their prey (Cade 1960; Brown 1976). In kestrels this handling behavior results in a ventral side down orientation of small mammal prey, which appears to increase the likelihood that kestrels will cache prey ventral side down. The results of Experiment 1 also show that kestrels place their prey open end first into a cache site opening and then push the remaining body in, rather than dropping the prey in tail first. This suggests selection for concealment as the open end is often bloodied. It is possible however that this behavior was selected to prevent rapid deterioration of prey. Mueller's (1974) observations that kestrels cache intact prey more frequently than skinned prey, which would deteriorate rapidly, support this latter notion. Second, the direction of fur may make it easier for the kestrel to eat mammalian prey head first as well as to push remains into cache sites head first (Frances Hamerstrom, pers. comm.).

The results of Experiment 2 show that confined kestrels appear hesitant to cache prey in the presence of a potential pirate and that when they do cache in the presence of an intruder they increase their use of cache sites that are obstructed from view of the potential pirate. These results as well as my observations of free-ranging kestrels in South Carolina indicate that kestrels use cache sites as hiding places for uneaten prey.

For some predators cached prey is the result of surplus killing (for mammals see Kruuk 1972a; for birds see Nunn, *et al.* 1976), and in most instances caching behavior appears to function as a mechanism that dampens oscillations in food intake (cf. Balgooyen 1976; Collopy 1977). If caching does function to minimize fluctuations in prey availability, two criteria must be met. First, animals must be able to find the prey they have cached and second, the cached prey must be relatively safe in its cache until retrieved. Numerous studies indicate that animals, including kestrels, that cache prey are capable of retrieving stored prey (Standell and Waian 1968; Kruuk 1972a, 1972b; Mueller 1974; MacDonald 1976; Nunn, *et al.* 1976; Oliphant and Thompson 1976; Collopy 1977). While most of these same investigators imply that prey is hidden from potential pirates, direct evidence is lacking. My experimental studies suggest that while dorsal orientation of cached mammalian prey may result from species characteristic prey handling during feeding, kestrels do indeed select caching sites that hide their prey from potential thieves. Additional support for a hiding function comes from field observations in Ohio (Bildstein 1978) which indicate that kestrels watch over cached prey and retrieve it when it is in apparent jeopardy. Furthermore, my observations in South Carolina demonstrate that free-ranging kestrels hide prey they are feeding on even when they are still hungry if they are approached by a potential pirate. Clearly, my experimental ma-

nipulations and natural observations strongly bolster the notion that kestrels hide and to some extent "protect" the prey they store.

Acknowledgments

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A PRAIRIE FALCON FLEDGLING INTRUDES AT A PEREGRINE FALCON EYRIE AND PIRATES PREY

by

David H. Ellis

Institute for Raptor Studies

Box 4420, OM Star Rt.

Oracle, AZ 85623

and

David L. Groat

Sarett Nature Center

2300 Benton Center Road

Benton Harbor, MI 49022

An unusual incident at a Peregrine Falcon (*Falco peregrinus*) eyrie in southeastern Arizona provides insight into the ability of adult falcons to recognize their own young and may have important implications in falcon reintroduction efforts. In 1980 Peregrine and Prairie (*Falco mexicanus*) Falcons nesting only ca 200 m apart engaged in a long series of agonistic encounters culminating in an episode in which a recently fledged Prairie Falcon entered the peregrine eyrie and received 3 prey items delivered by the adult peregrines.

Some remarkable interspecific behavioral sequences have been observed. Ratcliffe (1962, 1963) reported 2 instances of Peregrine Falcons apparently commandeering the eggs of European Kestrels (*Falco tinnunculus*) after the peregrines had apparently lost their own eggs. The peregrines successfully fledged the young kestrels in at least one of these attempts with no agonistic behavior noted between the adults and young. Cupper and Cupper (1981) reported a remarkable instance in which an adult Australian Kestrel (*Falco cenchroides*) responded to the energetic food begging of nestling Black Falcons (*Falco subniger*) only ca 50 m from its own nest by entering the Black Falcon eyrie and feeding the chicks. At the opposite extreme, C. M. White and J. H. Enderson (pers. comm.) found where a Peregrine Falcon killed a nesting adult female Rough-legged Hawk (*Buteo lagopus*) and subsequently laid their own eggs in the nest with the hawk eggs. In the account that follows both adult peregrines exhibited agonistic behavior toward the intruding congener.

Observations at the eyrie, where Groat was an assigned warden, began ca 2 weeks before egg laying and continued until 2 weeks after 2 young peregrines fledged. Over 650 observation hours were logged. Nearly all observations were made from a knoll ca 800 m from (and slightly below) the eyrie. Optical aids included a 20-45 x spotting scope and 10 x 50 binoculars.

Agonistic encounters involving the Peregrine and Prairie Falcons occurred in 54 bouts on 26 observation days. Near collisions were common and on 21 June a Prairie Falcon was struck at least twice by the adult female peregrine. Four probable strikes were also observed in that bout (2 by the male and 2 by the female peregrine). On 13 July, again in team attack, the adult female peregrine struck a Prairie Falcon. In nearly all of the encounters the peregrines were the aggressors and the peregrines dominated the combat.

Walton (1978) described an extreme example in which an adult male peregrine struck and apparently killed a Prairie Falcon after an extended aerial battle involving both peregrines. Cade (1960) observed a female peregrine grapple with a female Gyrfalcon (*Falco rusticolus*): both birds survived. Although none of Groat's observations resulted in death, in 1978 we found two dead Prairie Falcons (one a recent fledgling) below this same peregrine breeding cliff.

In the description that follows, the responses of the adult peregrines to the intruding juvenile Prairie Falcon must be judged in the light of this history of frequent interspecific agonistic encounters. Between 23 and 27 June the young Prairie Falcons fledged. On 28 June one young Prairie Falcon (hereafter prairie) followed the prey laden adult female Peregrine Falcon into the eyrie containing 4 week old young. An abbreviated log of this episode follows:

28 June 1045 The adult female peregrine with prey, arrived from the north wailing. As she landed at the eyrie mouth a juvenile prairie slipped past her into the eyrie. The adult female quickly left the ledge and stooped back and forth at the eyrie entrance loudly cackling. The adult female finally landed at the eyrie entrance and jabbed her foot into the narrow pothole (at the prey or at the prairie?). The adult female moved into the eyrie, but continually called. After about 3 min. the adult female left the eyrie and again stooped about the eyrie entrance cackling. After ca 5 min. the adult female perched ca 15 m from the eyrie but continued cackling.

- 1110 The juvenile prairie appeared at the eyrie entrance but at intervals walked deeper into the eyrie and fed. The large downy peregrine nestlings appeared unconcerned with the prairie.
- 1135 The adult female peregrine cackled less often now and the prairie, perched at the eyrie mouth, occasionally gave a food solicitation call.
- 1200 The adult female soared over the cliff and occasionally stooped at the prairie perched at the eyrie entrance. The prairie sometimes responded by scurrying back into the eyrie and calling or at other times by ducking as the peregrine passed.
- 1215 The adult female gave up the attack, soared off to the east and was lost to view.
- 1230 The juvenile prairie perched at the eyrie entrance.
- 1231 The adult male peregrine landed with prey. The juvenile prairie took the prey from the male and scurried deep into the eyrie. The adult male hesitated momentarily at the eyrie entrance, then flew out and stooped repeatedly at the eyrie mouth, cackling all the while. He attempted several landings at the eyrie but each time turned away. After protesting for about 5 min. the adult male left. The prairie fed at the eyrie entrance.
- 1240 One nestling peregrine fed at the eyrie entrance.
- 1247 Both nestling peregrines and the juvenile prairie with full crop perched side by side at the eyrie mouth.
- 1255 One nestling peregrine walked to the ledge brink and bobbed its head intently peering out. Soon the prairie joined it. The peregrine squatted by the prairie.
- 1330 The prairie at intervals walked to the eyrie entrance.
- 1400 The adult female peregrine arrived with prey. The prairie, perched at the eyrie entrance, squatted down and spread its wings as the adult arrived. The prairie snatched the prey and scurried into the eyrie. As at first, the female peregrine stooped and cackled at the eyrie entrance. She landed once at the entrance but quickly flew. After more cackling and hovering she landed ca 50 m from the eyrie.
- 1405 The adult female again stooped at the eyrie entrance barely touching down several times, then flew over to the prairie eyrie and returned. The adult female cackled incessantly while the juvenile prairie at intervals gave food solicitation calls.
- 1414 The adult female landed 15 m from the eyrie.
- 1415 The adult female stooped and cackled at the eyrie mouth ca 5 min., then perched again.
- 1430 The adult female flew near the eyrie entrance and perched ca 1 min., cackling at the prairie.
- 1431 The adult female returned to her more distant perch.
- 1500 The adult female left.
- 1533 The adult male perched ca 15 m from the eyrie and remained until the observation period ended at 1600.
- 29 June 0700 When the observation period began, the prairie was gone from the eyrie.
- 0745 The adult male arrived with prey and fed the young. The adult female perched nearby cackling.
- 0751 The adult male left the eyrie and, enroute to a perch ca 30 m away, nearly collided with a prairie. The prairie landed near the adult male. After ca 2 min. the adult male left and a second prairie appeared at this perch.
- 0753 Both adult peregrines repeatedly stooped at the first prairie nearly dislodging it.

In the foregoing incidents both adult peregrines were able to distinguish between the intruding prairie and their own young. Both adults responded aggressively while the young peregrines were apparently undisturbed by the intruder. The observations suggest, as has been learned from captive cross-fostering experiments (T. J. Cade and B. J. Walton pers. comm.), that in reintroduction attempts it is advisable to introduce downy young of the same age as natural siblings. A further suggestion from these observations is that productivity estimates based on fledgling counts in situations where eyries are in close proximity may sometimes be biased due to fledgling movements between family groups. Extreme values in the number of young fledged per eyrie, to be fully credible, should be corroborated by prefledgling observations.

We thank the U.S. Forest Service and the Rocky Mountain Forest and Range Experiment Station for support for our studies. Tom Deecken coordinated the 1980 field work. T. J. Cade, R. D. Porter, and C. M. White contributed supporting information and editorial suggestions toward the manuscript.

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OBSERVATIONS ON THE USE OF RANGLE BY THE PEREGRINE FALCON (*FALCO PEREGRINUS TUNDRIUS*) WINTERING IN SOUTHERN BRASIL

by

Jorge L. B. Albuquerque

Caixa Postal 10323

90.000 Porto Alegre, Rio Grande do Sul
Brasil

The use of rangle, or gastroliths was investigated and summarized by Fox (1976). Some questions arose from his observations and comments, namely: (1) How frequently is rangle used by wild falcons, and (2) What factors stimulate the falcons to use rangle?

Recently I have been involved in a study of the Arctic Peregrine Falcon, *Falco peregrinus tundrius* (Albuquerque 1978 and unpublished M.S.) wintering in Brasil. In the austral summer season, 1979, I observed one adult female on several occasions picking up gross grit from a sand storage on top of an old building under construction in downtown Porto Alegre. It was also recorded regurgitating this gross grit.

Field Observations

1. Porto Alegre (30°00' S, 51°10' W) 24 January 1979 at 1555. The adult female perched on top of an old building under construction, took a bath and picked up gross grit from a sand storage. *Remarks:* She consumed about 238 g of food over the last two days (119 g/day). I found carcasses in her favorite plucking place of the following prey species: 1 adult *Columba livia*, 3 rails (2 *Laterallus melanophaius* and 1 *Porzana albicollis*).

2. Porto Alegre, 14 February 1979 at 0545. She performed the same behavior as mentioned above. *Remark:* She ate 1 pigeon nestling weighing 120 g and 1 passerine of about 30 g over the 2 previous days and 2 passerines on this last day. One can tentatively estimate a food consumption of 210 g (105 g/day). In this instance, there is a decrease in food ingested from 105 g/day to 60 g/day on the last day.

At 0546 she regurgitated a significant portion of the gross grit swallowed minutes before. The grit was coated with mucous and her defecation was discolored like those described by Fox (op. cit.).

3. Porto Alegre, 16 February 1979 at 0634. She performed the same behavior mentioned above, except that regurgitation of grit was not noted. *Remarks:* Previously she was seen eating on 1 pigeon fledgling 2 days before swallowing the rangle, and was not seen eating anything on the previous day.

4. Porto Alegre, 3 March 1979 at 0613. She perched on a ledge of a waterfront building watching a rail flying close to the water (Albuquerque, unpublished M.S.). Before trying to intercept the rail, she regurgitated large amounts of gross grit. It was possible to see the sand and grit being cast up by the falcon. *Remarks:* She ate 1 fledgling the previous day.

5. Palmares (31°10'07" S, 51°20'08" W) 16 January 1980 at 1630. An adult female flew from a dirt road to a wet field as we approached in a vehicle. After a few minutes, she flew across the road to a termite mound and there cast up an object. Immediately thereafter, she began to hunt in a very direct manner, flying fast and coursing low over the ground. We later examined the termite mound to gather possible prey remains, but instead we found 2 large stones (12 × 10 mm and 20 × 20 mm) like those on the dirt road. They were moist and had an acrid smell. Her feces on the mound were dark and of oily appearance similar to those of an unfed captive falcon (C. M. White, pers. comm.).

Discussion

The theory on functions of gastroliths in seals and sea lions (Emery 1941), that on trituration, to crush worms and alleviate ulcers could also be correct for birds. The triturations function seems unlikely in raptors (Fox 1976), but rangle could stimulate and promote gastric secretions. Both mechanical and chemical stimulation act on gastrin producing cells and gastrin stimulates the secretion of hydrochloric acid (Jorgsen, 1977).

Falcons observed in Porto Alegre and Palmares performed hunting behavior sequences in association with the use of rangle. In both places they had fasted or at least gone without recent food when recorded using rangle, either in the morning or in the evening. In terms of an energy budget, it is advantageous to the predator to use one behavior that contributes to the maximization of its digestive efficiency.

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BOOK REVIEWS

Hawks in Focus. Jack and Lindsay Cupper. 1981. Jacklin Enterprises, Mildura, Australia. 208 pp, 315 photos, 26 maps. \$29.50 U.S. (obtainable through Jacklin Enterprises, P.O. Box 348, Merbein, Vict. 4505, Australia, plus postage, approx. \$2.00).

This is a delightfully written book, especially for one familiar with Australia. As I read about the dust storm with fierce hot winds approaching the authors as they photographed from a tower, the all too vivid recollection of my experience in the mallee of Victoria with dust so thick in the air it could be cut, and high winds of temperatures exceeding 100°F, came to my mind. My experience was exciting and I was gripped with nostalgia as I read about theirs. By the same token, the one minor complaint or drawback I found with the book is the sometimes lengthy discussions of the authors' trials, tribulations and experiences, but which really had nothing to do with raptors. It is by design, however, that the authors describe their feelings about their work and their adventures so that the reader may visit all 24 species of diurnal raptors of Australia vicariously. For each species photographs show a normal egg clutch, adults at the nest with young, the adult perched, a bird in flight, and generally a habitat view. In a random sample of 5 species there were on average 13 photographs per species (range 6-20).

Anyone who has tried to climb 20-30 meters up a eucalyptus tree knows how difficult they are to negotiate and accordingly the photos were taken from a blind located on top of a metal tower erected by the nest tree. The only nests not shown to be in trees were one of an Osprey (*Pandion haliaetus*) and one White-Bellied Sea-Eagle (*Haliaeetus leucogaster*) on rocky pinnacles and those of the Marsh Harrier (*Circus aeruginosus*) on the ground. Australia has some incredibly interesting raptors, notable are the Letter-Winged Kite (*Elanus scriptus*) which, along with the Bat Hawk (*Machaeerhamphus alcinus*) of Africa and Southeast Asia, is a nocturnally hunting "diurnal" raptor and the Spotted Harrier (*Circus assimilis*), the only tree nesting member of the genus.

The authors made some exciting observations from the blind. They saw an adult breeding Australian Kestrel (*Falco cenchroides*) fly to and feed young Black Falcons (*Falco subniger*) that were giving food begging calls in their nest. This smacks of the observations of Ratcliffe (British Bird 56:457, 1962) where kestrels were raised by peregrines (*Falco peregrinus*). They watched a female Brown Falcon (*Falco berigara*) remove one of her dead chicks from a nest just as she did remainders of food not eaten. Removal of uneaten food is an interesting behavior in itself especially if one is familiar with the lack of nest cleaning so common in other large falcons, such as the peregrine, where even dead young remain in their nests if not cannibalized by sibs. Some of their recordings attest to the value of observations from blinds. As further testimony to the value of studies from blinds, I am reminded of a recent conversation with my colleague William Mader where, in checking food remains in nests of a South American hawk, no remains of eels were found (N = 160 remains) but based on observations from a blind at

one of the same nests previously checked, 45% of the food brought in (42% by biomass) were fresh water eels; items totally missed by other means of food studies.

Three of the photographic studies were of particular interest to me. First, photographs of the Grey Falcon (*Falco hypoleucus*), an uncommon falcon of the drier parts of Australia, are the first to have been published showing adults at the nest as far as I can determine. Second is the remarkable documentation of the Black-Breasted Buzzard (*Hamirostra melanosternon*), a type of kite, raising a brood of kestrels. Apparently the buzzards fed on young kestrels and some brought to the nest as food were not killed; as the kestrels gave food begging calls the buzzard responded with stereotypic appropriateness and did so until the young kestrels were grown and fledged. Lastly, is the record of the natural hybrid between two species, the white phase of the Grey Goshawk (*Accipiter novaehollandiae*) and the Brown Goshawk (*Accipiter fasciatus*). Pictures I saw elsewhere of the first adult plumage of the hybrid offspring were not unlike the grey phase of the Grey Goshawk and it is indeed unfortunate the Cuppers did not include a picture of the molted bird in their book. Of interest is that pair was not at the periphery of the range of either species where one might expect hybridization to occur and the pair bond lasted more than one year.

They state that the Brown Falcon was recorded building its own nest. I have heard the same thing from Australian falconophiles but I saw no evidence that unequivocally convinced me that the species does build a nest. If they do, they are the only one of 36 species of *Falco* to do so. Unfortunately the Cuppers were unable to document this on film. Had they, it would have been a significant contribution to our knowledge of this somewhat different *Falco* species and indeed *Falco* in general.

The casualness of not only the humor but the descriptive statements in the book reflects the directness and at the same time subtleness typical of Australians. For example, of the Black Kite (*Milvus migrans*) it was said "unlike most other young birds they did not back to the edge of the nest to defecate. Instead they lowered their head, raised their rear-ends and ejected howitzer-like from the cup of the nest." They vividly described the incredible rapidity that soils in the interior gum up and become slick with the slightest moisture. As they returned from photographing Black Falcons they drove down one wet track where "it looked like a squadron of tanks had been holding maneuvers on it. With more than a modicum of luck, coupled with the expertise acquired through a lifetime of driving on out back tracks we managed to keep mobile most of the time, although we weren't always facing in a homeward direction."

I thoroughly enjoyed the book not only for its readability, but for the biological observations shared. Most of all, are their magnificent photographs. Once having read the book, it is impossible not to grasp the spectrum of opportunity in studying the remarkable array of Australian raptors.

C. M. White

THESES AND DISSERTATIONS

DISTRIBUTION OF DDE RESIDUES IN PREY SPECIES OF CALIFORNIA PEREGRINE FALCONS

A total of 18 inviable peregrine falcon (*Falco peregrinus anatum*) eggs obtained in California during 1980 and 1981 contained a geometric mean concentration of 19.5 parts per million of DDE, wet weight, indicating that environmental levels of this pollutant are still sufficiently high to impede reproduction at many nesting sites. Principal prey species of the peregrine falcon were analyzed individually for DDE and PCB residues. Among resident prey species, DDE levels in the mid-coastal area, where natural productivity remains very low, were an order of magnitude higher than in the northern interior, where the majority of peregrine falcons are currently breeding. Highest DDE levels were recorded in killdeer (*Charadrius vociferus*), starling (*Sturnus vulgaris*), and American robins (*Turdus migratorius*). In addition, several other species known to migrate from Latin America to California also contained DDE levels considered to be harmful to peregrine falcons. Consumption of a single individual of contaminated prey could significantly increase the levels of DDE and other organochlorine biocides in peregrine falcon eggs.

Monk, James Geoffrey. 1981. Distribution of DDE residues in prey species of California peregrine falcons. M.S. Thesis, University of California, Berkeley. 29 pp.

PRAIRIE FALCON FLEDGLING PRODUCTIVITY IN THE MOJAVE DESERT, CALIFORNIA

Mean Mojave Desert prairie falcon fledgling productivity, over a six year period during the 1970s, was below the continental mean for the species and outside the lower limit of the 95 percent confidence interval. Human disturbance was thought to be responsible for the low fledgling productivity. I studied human disturbance and physiographic variables at prairie falcon nesting sites from 1977 to 1979 to determine whether fledgling productivity was in any way related to these variables.

Significant differences in mean values between successful nests (fledging 3 to 5 young) and unsuccessful nests (fledging 0 to 2 young) were found for elevation of the nest, position of the nest with respect to the bottom of the nesting cliff, the amount of time required to walk to the nest from the nearest road, the number of roads near the nest, ease of which the cliff can be climbed by humans, shooting, and eggshell thickness. The aforementioned variables, except for eggshell thickness, are all variables that isolate prairie falcon nests from man. Nests that were easily accessible to man had significantly lower productivity than nests in more remote locations. Evidence of man-created chemical pollution also exists because mean prairie falcon eggshell thickness was 14.5 percent thinner than pre-DDT levels. Human disturbance appeared to play a significant role in affecting prairie falcon fledgling success in the Mojave Desert.

Boyce, Douglas A. Jr. 1982. Prairie Falcon fledgling productivity in the Mojave Desert, California. M.S. Thesis, Humboldt State University, California. 97 pp.

ABSTRACTS

SPACE AND HABITAT UTILIZATION BY RED-SHOULDERED HAWKS (*BUTEO LINEATUS ELEGANS*) IN SOUTHERN CALIFORNIA

I studied the movements of 5 adult Red-shouldered Hawks, 4 of which I radio-tagged, on Camp Pendleton Marine Corps Base, San Diego Co., California for a total of 941 hours between February 1979 and May 1980. Maximum breeding home ranges of males (mean = 61.8 ha) were larger than, and encompassed, the ranges of their mates (mean = 36.8 ha). Percent overlap between adjacent pairs ranged from 6–11% (mean = 8.4%). Changes in space use corresponded with different phases of the reproductive cycle. The least amount of space was utilized during the non-breeding period, while during reproduction, changes in space use were related to the sex of the individual, energy requirements, and territorial activity. Habitat utilization was greatly influenced by the "sit and wait" hunting technique of the individuals studied. Wooded habitats were used most heavily, while the use of open areas was often entirely a result of the presence of man-made perch structures. Differential use of wooded habitats seemed to be influenced by hunting perch structure. Territorial activity was observed throughout the study but increased to a peak during the pre-hatching phase of reproduction and declined to a low level after hatching. Territories encompassed a large portion of maximum breeding home ranges (66.6–94.1%). I also discuss territorial behavior, interspecific interactions, and population status in California.

McCrary, Michael D. 1981. Space and habitat utilization by Red-shouldered Hawks (*Buteo lineatus elegans*) in southern California. M.S. Thesis, California State University, Long Beach, California.

Present address: 5927 Lakewood Blvd
Lakewood, California 90712

MULTIVARIATE ANALYSES OF WEATHER AND FALL MIGRATION OF SAW-WHET OWLS AT DULUTH, MINNESOTA

The relationship of saw-whet owl (*Aegolius acadicus*) migration to local weather conditions was investigated using synoptic, bivariate, and multivariate techniques. A total of 1401 saw-whet owls were netted at the Hawk Ridge Nature Reserve, Duluth, Minnesota from 1974 through 1978. Weather data were obtained from the Duluth National Weather Service station, 12 km west of the study area. Factor analysis, based on the original weather variables, was used to derive a group of uncorrelated weather factors, each representing a basic characteristic of weather. A multiple regression model, based on weather factors and temporal and moon related variables, accounted for 43% of the variability in migration volume. Peak migration was associated with conditions following cold front passage, i.e. increasing barometric pressure and cooler temperatures, but was suppressed when winds were gusty or exceeded 10 knots. Migration tended to diminish during a several day period prior to full moon. Northwesterly winds were significantly correlated with migration volume, as reported in previous studies, but were much

less important in accounting for changes in migration volume than windiness, barometric pressure, and temperature.

Evans, D. L. 1980. Multivariate analyses of weather and fall migration of saw-whet owls at Duluth, Minnesota. M.S. Thesis, North Dakota State University, Fargo. 49 pp. (Current address: 2928 Greysolon Rd., Duluth, MN 55812).

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BURROWING OWL COLORMARKING: REQUEST FOR INFORMATION

In 1982 burrowing owls were colormarked in south-central Saskatchewan during a research program investigating movements of these owls during the breeding season. Information is requested from anyone seeing a colormarked owl to aid in determining migration routes and wintering areas which are presently unknown. Each owl carries a Fish and Wildlife band and from one to three colored plastic leg jesses. Jess colors are yellow, fluorescent red, light blue, and dark green and are one centimeter wide and extend approximately 1.5 cm beyond the leg. Persons observing colormarked owls please record the following: location, date, color and position of leg jess or jesses, leg of attachment of metal leg band and jess or jesses, and any details of the owl's situation. Please send this information to, Bird Banding Office, Canadian Wildlife Service, Ottawa, Ontario, Canada, K1A 0E7 plus an additional copy to the bander, Elizabeth A. Haug, Dept. of Veterinary Anatomy, University of Saskatchewan, Saskatoon, Saskatchewan, S7N 0W0. Thank you for your assistance.

REQUEST FOR INFORMATION

As part of a project to re-establish Swallow-tailed Kites in southern Kansas and to study the population biologies of this species and the Mississippi Kite, individuals of both species are being color banded. Some Mississippi Kites have also been given a colored patagial streamer on each wing. It would be appreciated if observations of these marked individuals, including color and condition of the markers and activity of the birds, were reported to the Office of Migratory Bird Management, Laurel, Maryland 20708 with a copy to Dr. Jim Parker, Department of Sciences and Mathematics, University of Maine at Farmington, Farmington, Maine 04938.

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